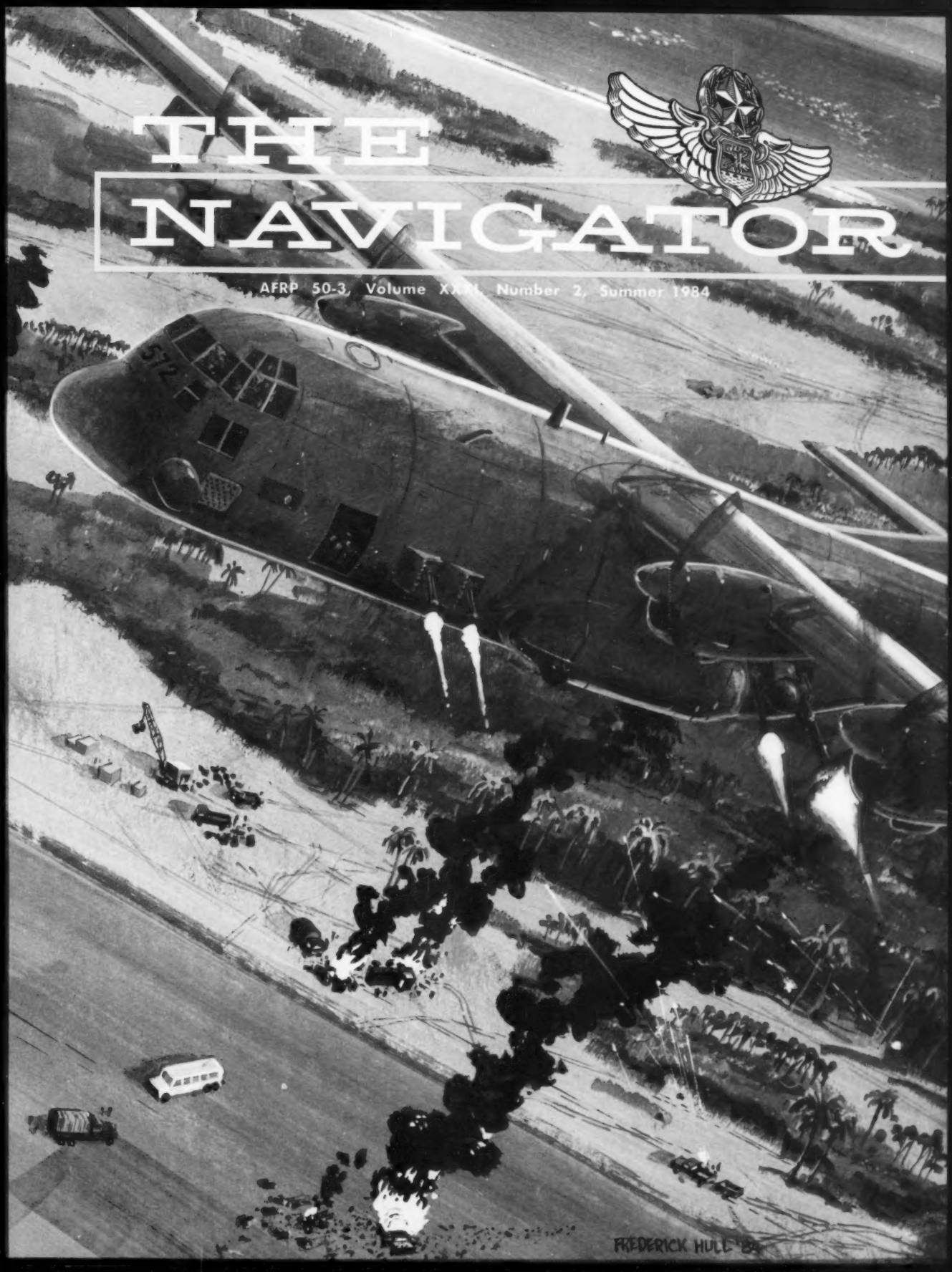
THE
NAVIGATOR
AFRP 50-3, Volume XXXI, Number 2, Summer 1984
FREDERICK HULL '84

NAV OF NOTE

LIEUTENANT COLONEL GARY R. HINKLE

Lieutenant Colonel Gary R. Hinkle is Deputy Commander of the 7th Combat Support Group, Carswell AFB, Texas. He came to the position after compiling an impressive record of achievement as Commander of Carswell's 20th Bombardment Squadron.

In 1964, Colonel Hinkle earned his commission through the ROTC program at the University of Colorado. After receiving his navigator wings and completing navigator-bombardier training in 1966, he was assigned to combat crew duty with the 17th Bombardment Wing, 34th Bombardment Squadron, Wright-Patterson AFB, Ohio, flying B-52E and H models. In January 1970, he transferred to the 99th Bombardment Wing, Westover AFB, Massachusetts, for his introduction to the B-52D. In March, he left Westover for temporary duty in Southeast Asia where he flew 83 combat missions in support of Arc Light operations.

Upon his return to the United States, Colonel Hinkle attended Squadron Officer School at Maxwell AFB, Alabama. Completing his tour of duty with the 99th Bombardment Wing in July 1971, the colonel was selected to attend the Graduate School of Business at Oklahoma State University where he earned an MBA through the Air Force Institute of Technology in December 1972.

Expanding his horizons in the Air Force, Colonel Hinkle next entered combat crew training in the AC-130 gunship. As a special operations navigator, he flew 42 combat missions while assigned to the 16th Special Operations Squadron, Ubon, Thailand.

The management side of Colonel Hinkle's career blossomed after his return from Southeast Asia in June 1974. After completing the Central Procurement Officer Course at Lowry AFB, Colorado, he moved to Kelly AFB, Texas. There, his service as a procurement/contracting officer gained him valuable experience in all phases of the contract award process.

Colonel Hinkle's duty with the Air Logistics Center at Kelly AFB was his first non-flying assignment. In logistics, the colonel discovered "...a whole different Air Force. I gained a deep appreciation for the complexities of the system that supports our operational commands." The job also afforded Colonel Hinkle his first opportunity to formally lead and supervise—experience valuable to any future commander.

Comparing the procurement world with the operational arena, Colonel Hinkle identifies one of the main differences as working closely with civilians. As a contracting officer and section chief he supervised 12 civilians, GS-4 through GS-12. He emphasizes that they are hardworking, motivated people, just as dedicated to the Air Force as their military counterparts.

Another contrast between procurement and operations, noted by Colonel Hinkle, is the end result of one's efforts. "In operations, it's difficult to measure success, especially on a day-to-

day basis. Nuclear deterrence, for example, is a comparatively abstract concept. The successful negotiation and award of a contract is concrete proof of one's work." Regarding leadership challenges, however, Colonel Hinkle sees little difference between operations and other fields. "Whether you command a flying unit or a support organization, the principle is the same: orchestrating the efforts of a group of people to get the job done."

Before assignment to Carswell AFB, Colonel Hinkle was a distinguished graduate of the Air Command and Staff College, completing the program in June 1978. Shortly after joining Carswell's 9th Bombardment Squadron, Colonel Hinkle became Chief, Instructor Flight. As such, he oversaw the integration of the Digital Bombing and Navigation System (DBNS) into the SAC inventory. "The DBNS gave us the needed confidence to penetrate at low level and navigate to a target without popping up to obtain radar fixes." Successfully implementing the DBNS into Carswell's combat inventory was, in part, a product of Colonel Hinkle's ability to train, manage and lead his personnel.

Colonel Hinkle served as Operations Officer for the 9th Bombardment Squadron for nearly one year before he was selected to command the 20th BMS in July 1982. As the first navigator commander of a tactical bombardment squadron, Colonel Hinkle was an inspiration for navigators in the squadron, as well as those throughout the Strategic Air Command.

Colonel Hinkle foresees a bright future for other navigators aspiring to command positions. He recalls, then USAF Chief of Staff, General Lew Allen's policy statement from March 1979, that "Navigators who demonstrate leadership potential should be professionally developed and considered for operational command at all levels along with similarly qualified pilots." The colonel emphasizes that the transition won't happen overnight. Tradition changes slowly.

Reflecting upon his squadron command experience, Colonel Hinkle sees no difference between having a navigator or pilot as commander. "All commanders, whether pilots, navigators or nonrated officers, must rely on the advice and expertise of their specialists—that's why we have staff personnel. However, the colonel does perceive a built-in organizational advantage for pilots to develop leadership skills. "Pilots, at least in SAC, are placed in formal leadership positions at a relatively early stage in their careers, usually when they become aircraft and crew commanders. So by the time they enter competition for higher-level command positions, they have several years of solid leadership experience behind them." One way for navigators to make up for this organizational handicap, suggests Colonel Hinkle, is for them to maintain positive attitudes and seek opportunities for increased responsibility.

"Navigators must use every opportunity to broaden their technical backgrounds and military education. Volunteer for the toughest additional duties in your unit. Look for projects requiring extensive coordination with other personnel and agencies. Work on communicative skills through professional military education and other programs."

Reviewing the achievements of his squadron command service, Colonel Hinkle is pleased with the 20th Bombardment Squadron's record. Under his leadership, the squadron came through with flying colors during an Operational Readiness Inspection, a "Buy None," and a Global Shield exercise.

Having moved on to even bigger opportunities with the 7th Combat Support Group, Colonel Hinkle greets new challenges with optimism and pride as he seeks new horizons in his already distinguished career.

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Department of the Air Force

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On the morning of October 25,1983, US forces dramatically rescued American medical students near Pt Salines airport on the Caribbean island of Grenada. USAF MC-130s and AC-130s played key roles in that rescue. Our cover depicts an AC-130 Spectre gunship, overhead Pt Salines, delivering defensive fire for US Army paratroops. A navigator's account begins on the following page.

Distribution: One copy per four navigators.

FURY in the SPICE ISLANDS:

Captain Bryan A. LASYONE
16 SOS
Hurlburt Fld, FL

A Navigator's Mission

One of the first things I learned at Hurlburt Field was the 1st Special Operations Wing's motto: "Anytime, Anyplace." Three years later, I would gain a fuller appreciation for what it really means.

Four hours! The amount of absolute chaos that can be packed into four scant hours is incredible.

1330: On Monday, I was at home wondering if my long weekend telephone alert would amount to anything—I called in.

1335: I was on my way to the squadron.

1400: I had joined a large group of aircrew members for the briefing.

1405: The atmosphere was thick with anticipation—we were going into combat! Our mission would be to provide surgical firepower for a joint rescue operation to free American medical students near Point Salines Airport, Grenada. The opposition was a cadre of tough, dedicated Cuban "engineers" whose airfield construction equipment included several 23mm AAA pieces and numerous four-barreled .50 caliber heavy machine guns. We were told that the Cubans might surrender; to fire only if fired upon.

2330Z: We were airborne.

The rescue mission's length required crew augmentation in the positions of pilot, flight engineer, navigator and illuminator operator. The second navigator and I decided that I would see the early action. He would take over later on.

After 9½ hours and two air refuelings, we arrived on station over Grenada—the Island of Spice as it was named on the charts. In the predawn darkness, we established our standard left-turn orbit over Point Salines and waited. The left orbit shows the AC-130's business side—the side with the sensors and guns.

News arrived that the lead MC-130 Combat Talon had experienced equipment problems and was delayed. The wait seemed forever. As the first streaks of daylight began spreading, some of us tried to push the sun back over the horizon by force of will. Finally our electronic warfare officer (EWO) began calling the lead Combat Talon's progress to us on the interphone. His voice droned, "three minutes out...two minutes...thirty seconds." We

strained our eyes to see the low-flying Talon. Suddenly, we spotted him—just off the end of the runway. Just as suddenly, our battle of wits with the sun was lost. Everything was aglow in the morning light. As Army Rangers poured from the Combat Talon, the "engineers" unleashed their AAA with a determined rage. It was time for us to go to work.

View of Pt Salines runway from west. Black Bay and Cato Bay on right.

We put a visual sensor on the nearest AAA site, rolled in and returned fire for the defenseless Talon. The Cubans quickly realized that the grey AC-130 orbiting overhead was hostile. They elevated their guns to concentrate on us. Their attention shift had three noticeable effects. It gave the Rangers time to organize, it drew fire from the Talons, and it gave us all the reason in the world to shoot back. In the exchange of gunfire that followed, we gave quite a bit more than we got. We were soon seeking new targets. Our fire control officer struggled with a balky fire control computer to keep the guns shooting.

Our attention quickly shifted to another target—an imposing cluster of AAA pieces. Perched on a hilltop overlooking the runway, the guns were sighted to fire down upon the Rangers' landing zone. Protective cover in and around the runway was pretty scarce. The ground forward air controller (FAC) had finished setting up by now. He directed our fire to the hill and toward the airport terminal buildings which housed a large group of heavily armed "engineers."

As Cubans began advancing on the FAC's position, he "walked" our fire closer in. With cannon rounds hitting less than 100 meters from him, I called a warning. He replied, in effect, that unless we fired even closer, he'd be dead anyway.

The urgency in his voice was plain, along with the sound of small arms fire in the background. After instructing him to take whatever cover he could find, I cleared the pilot to fire again. We put several dozen 40mm and several hundred 20mm rounds within 50 meters of his position—all this with an ailing computer. You quickly learn to work with what you have. We also took out two mortar emplacements the FAC had spotted. His gratitude was both obvious and heartfelt.

UH-60 Blackhawks return Army Rangers from fire fight.

82nd Airborne troopers shell hills over Pt Salines.

At this time, we started to run low on ammunition. Fuel quantity also became a primary concern. We called in a second gunship to avert any lapse in target coverage. After firing one final burst at the bad guys, we left the area.

The unofficial tally was four 23mm twin-barreled AAA cannons disabled, two .50 caliber heavy machine guns knocked out, two mortar emplacements destroyed, and several groups of "engineers" dispersed. We had been airborne over 17 hours; our final crew day exceeded 30 hours. Still, we were ready to go back. At mission's end, the adrenalin kept me up for another six hours.

USAF air base defense team establishes perimeter.

With the Grenada rescue behind me, I'd like to share a few observations with you. First, I now understand clearly why we train so much. When the bad guys are trying to spoil your day with cannon fire, you have no time to ask questions or "look it up." You simply act. Your actions are directly linked to your training. Conditioning takes over completely. Things like fear, anger, and discomfort occupy only enough of your mind to keep you razor sharp. The whole experience seemed like a massively realistic simulator ride—the primary difference being that mistakes could be deadly. So you don't make any.

Second, I really gained admiration for the Talon crews and the Army Rangers. It takes some giant kind of courage to fly low, slow, and straight enough to drop paratroops while AAA tries to knock you out of the sky. And to hang from a parachute under fire? Incredible!

Third, and most important in my mind, is what I learned about being part of an aircrew. Those 17 other guys on my crew became as important to me as my own family. We acted

C-130 offloads supplies. Note earthwork and airport tower framework in background.

View from Pt Salines taxiway. Note Soviet aircraft parked in grass at rear.

as one finely tuned defensive machine, spewing forth fire and respectability for all the world to see. I'll trust my life to any one of them. I did, in fact, for 17 hours.

Oh, yes. About that 1st Special Operations Wing motto...the aircrews of the 1st SOW are ready—anytime, anyplace. That's what it really means.

Capt Lasyone earned his BA in History from Angelo State University in 1979. After finishing UNT in 1981, he completed initial C-130 training at Little Rock AFB. Capt Lasyone presently serves as an AC-130 navigator.

OMEGA UPDATE

Major Michael J. SIEVERDING
34 TATG/TTX
Little Rock AFB, AR

Omega navigation equipment currently is used to position ocean-going ships, commercial and general air carriers, and military aircraft throughout the world. The Omega system offers significant advantages over its predecessor, LORAN, because it provides full-time, worldwide coverage. Eight transmitters broadcast Omega signals on 10.2, 11.33 and 13.6 Khz. Each transmitter emits a unique ten-second frequency pattern with extreme precision and uniformity. The method for transmitting Omega signals has remained much the same over the last decade; however, the methods for receiving those signals and determining a fix have changed considerably. Improvements to Omega receivers are occurring faster than our ability to accurately describe them in professional periodicals, FLIP, and AFM 51-40. Perhaps more misconceptions surround Omega theory and operation than any other piece of navigational avionics. Since these misconceptions may contribute to position error, we must correct them.

Misconception #1: Omega is a hyperbolic system.

Although this misconception appears to be academic, it is central to understanding Omega operation and must be treated first. Two different types of receivers have been built to use Omega signals: hyperbolic and ranging. Hyperbolic Omega receivers treat the signals as a LORAN receiver does by measuring the time delay between received signals. The new AFM 51-40, Chapter 18, offers an excellent description of a hyperbolic system. Omega ranging receivers treat signals in a manner similar to distance measuring equipment (DME). Therefore, the ranging receivers can determine a fix when receiving signals from as few as two stations, while hyperbolic receivers require signals from at least three stations to compute a fix. The C-130 Omega (AN/ARN-131) employs a ranging receiver designed to require three-station reception.

Misconception #2: An Omega lane is _____.
(Take your pick.)

a. 36 nm wide (ref: AFM 51-40)
b. 32 nm wide (ref: TO-1C-130B-1)
c. 8 nm wide (ref: Omega NOTAMS)
d. None of the above

The correct answer depends on the type of Omega receiver you use. For the C-130 Omega, your answer should be "none of the above." The AN/ARN-131 determines its position within the interference pattern of the 10.2 and 13.6 Khz Omega signals. This interference pattern repeats itself every 48 nm as signals emanate from the transmitters. If the C-130 Omega position is in error by 24 nm or more, the receiver processor may not be able to resolve

the correct position. A C-130 Omega lane is 24 nm wide. The lane referenced in NOTAMS is not a C-130 Omega lane. The NOTAMS describe the lane for a shipboard, single-frequency (10.2 Khz) hyperbolic Omega receiver—a nominal lane width of 8 nm. When the NOTAMS warn of ionospheric disturbances and state, "...errors as great as ½ lane may occur," a C-130 navigator should treat that ½ lane as a possible 4 nm error, not a 12 nm error.

Misconception #3: Navigators should manually deselect Omega stations IAW the FLIP Planning Document, General Planning, pages 10-15.

This statement is true only if you are using an Omega receiver without deselection logic built into its software, or if your receiver's deselection logic allows it to use problematic signals—those affected by environmentally-induced errors, propagation anomalies, and other interference. (The new AFM 51-40, Chapter 19, describes signal reception interference factors.) The C-130 Omega's internal software is much smarter at deselecting stations than a navigator using the FLIP chart. Manual deselection of a FLIP-listed station could eliminate the necessary geometry for primary-mode operation and push an otherwise valid Omega position "into the weeds." If certain stations might cause a problem, your receiver's software will usually deselect them when appropriate. The operator should, therefore, permit the machine to decide which stations it deselects. An exception to this rule is when the NOTAMs warn of polar path errors. The amount of error this condition causes, however, usually is not worth the risk of forcing your machine out of its primary fixing mode.

As a general rule for Omega ranging receivers, if one of your received stations is causing a position error, the error will be toward or away from the great circle direction of the problematic transmitter. You can gain an improved Omega position by deselecting the station that lies toward or away from the direction of your position error. This is possible if you know the direction of the Omega position error, the great circle bearings to Omega transmitters, and are receiving four stations or more. The small Mercator chart in FLIP is a very poor indicator of great circle direction. Use the following guidelines to determine when manual station deselection is appropriate.

Manual deselection of Omega stations should be accomplished if:

1. The station is NOTAMed out for calibration.
2. The NOTAMs warn of polar path lane errors and you are receiving four stations or more.
3. Your Omega position error is toward or away from the station (to be deselected) and you are receiving four stations or more.
4. You've tried everything else in the book and your machine still won't work.

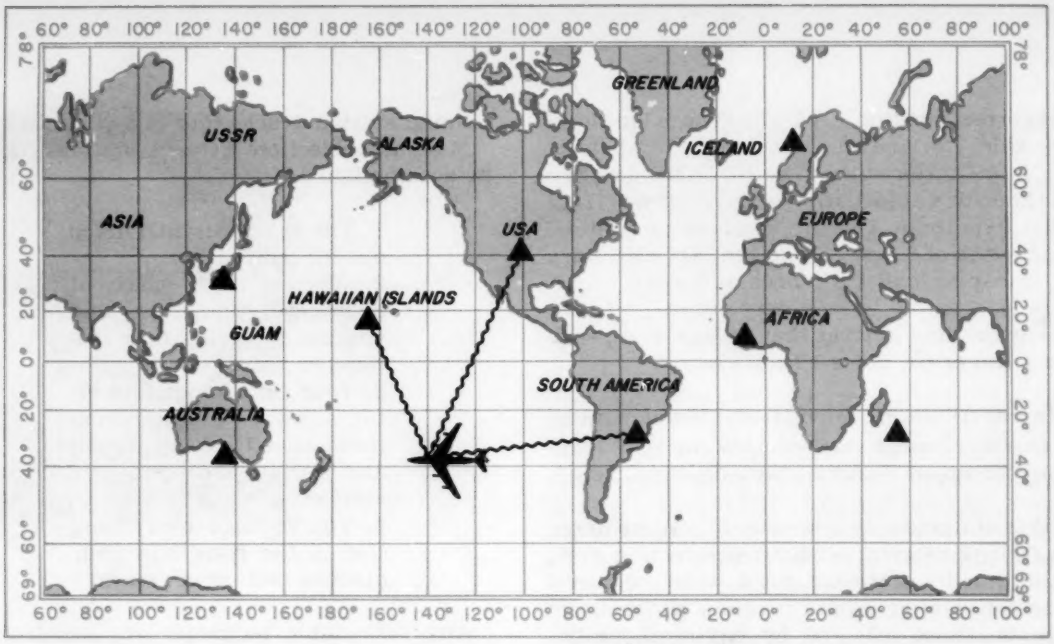
Any reasonable technique for deselecting stations necessitates constant monitoring of your Omega position and signal reception. No technique can beat that advice.

Misconception #4: If my Omega isn't working, there is little I can do about it.

Besides the conditional manual deselection just described, several other troubleshooting techniques (some of which border on metaphysics) may be employed. These include:

1. Turn off the VORs. This may sound odd but, in the C-130, wires carrying VOR signals to the front of the bus are located in the same 30-foot long wiring bundle containing the Omega antenna coaxial cable. VOR data is transmitted through the wires by an FM carrier wave with a high frequency end of 9.999 Khz. The C-130 Omega needs a steady 10.2 Khz signal. Either the VORs or the internal Omega signal filters can be slightly out of calibration. If so, VOR signals may interfere with Omega signal reception. If you do turn off your VORs, remember to turn them back on prior to coast-in!

2. Insert a false GMT. The C-130 Omega deselection logic is usually conservative. It was based on theoretical propagation models. After conducting validation studies of real Omega signals, the Coast Guard found, in many cases, that the signals behave better than originally anticipated. The C-130 Omega



Omega ▲TRANSMITTER LOCATIONS

sometimes deselects a station that is giving you reliable and necessary data. You can preclude this by initializing your Omega with a false GMT. This method, called "time-forcing" makes the machine believe it is daytime, and that a nighttime modal condition does not exist. Modals are Omega signals that do not behave in ways the Omega receiver can reliably interpret. Initialize your Omega with a GMT (or CUT) that implies daytime conditions between you and the station you need. If you do time-force your Omega, remember that ETAs from your machine will be erroneous and that you will have eliminated the receiver's built-in insurance against nighttime modal signal error.

3. Wipe off your antenna during preflight. (Kissing the antenna does not help!)

4. Deselect all stations, then cancel the deselect. This forces the machine to reevaluate signal reception from each station. A present position update or an in-flight reinitialization accomplishes the same thing.

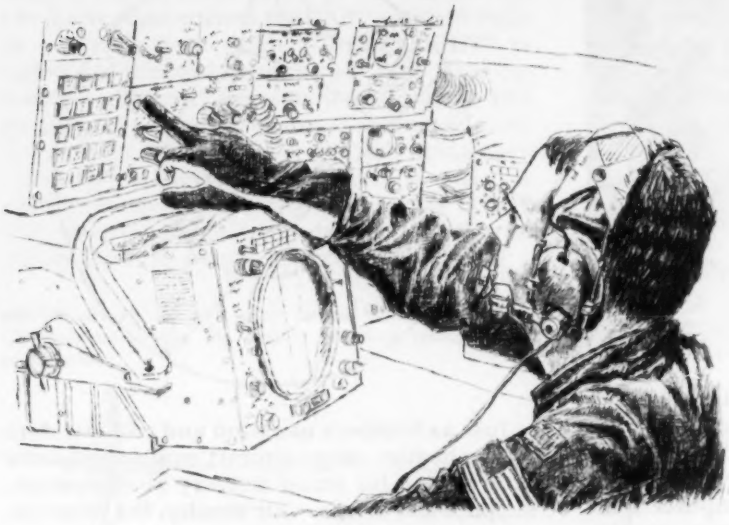
5. Continue to practice your celestial and pressure skills.

Since Omega became operational in the USAF, many misconceptions have led navigators to make otherwise avoidable position errors. As we become smarter in using this machine called Omega, we must disseminate our newfound knowledge and the lessons of experience. Significant improvements in Omega technology have occurred in the last several years. The C-130 Omega can still be vastly enhanced to provide increased reliability and accuracy—perhaps up to the FAA-certified standards enjoyed by Omega users in the civilian community. For this to happen, practicing navigators must make inputs, through command channels, concerning Omega operation. The function of a worldwide system like Omega can be confidently improved only with the knowledge gained from universal experience in a variety of tactical applications.

The author welcomes any comments concerning Omega operation. Please direct correspondence to THE NAVIGATOR.

A 1969 graduate of St Cloud State University, Minnesota, Maj Sieverding was commissioned via OTS. After UNT, he was assigned to Clark AB. Next came assignments to RC-130A photo mapping, the WC-130 at Keesler AFB, and instructor duty at Mather AFB. Major Sieverding now is a C-130E Simulator Certification Team member.

The C-130 AWADS:



Weather or Not

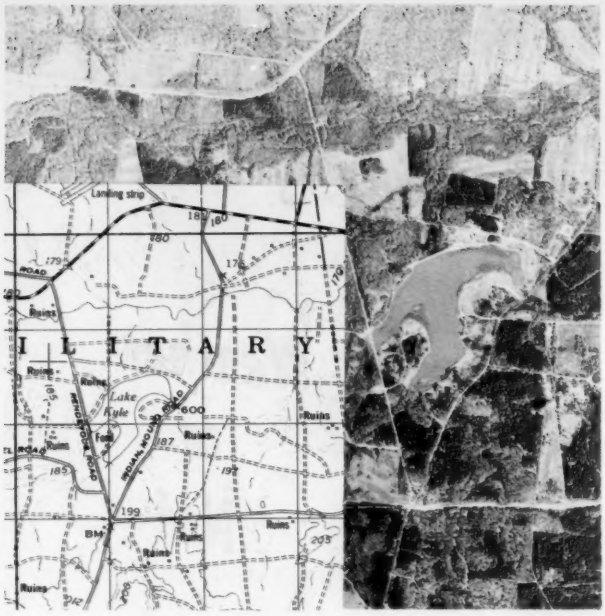
First Lieutenant Robert D. BURTON
1300 MAS/DOL
Howard AFB, Panama

The C-130 Adverse Weather Aerial Delivery System (AWADS) is a complex navigational system little understood by those not operating it. For anyone not intimately familiar with AWADS, I'll explain what the "smart" C-130s do and how they do it.

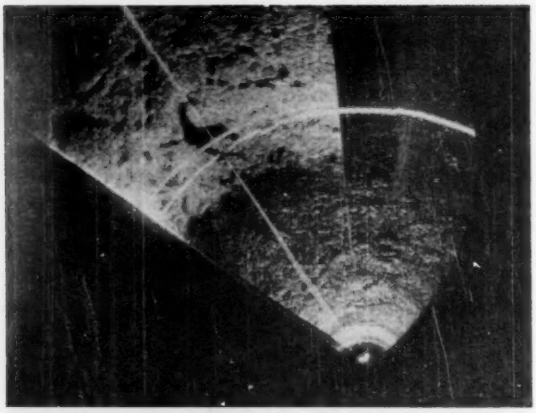
Conventional C-130 navigators fly low-level routes visually, or with radar if turn points are radar identifiable. For dead reckoning (DR), they employ a Doppler computer, Doppler drift and ground speed information, and preflight weather information. The conventional C-130 navigator also must be able to visually acquire the drop zone (DZ). If bad weather obscures the DZ, a no-drop situation exists and the air drop is postponed.

The AWADS navigator is aided by an ASN-24 DR computer and the Ka-band radar. The ASN-24 affords the AWADS navigator a radar update capability, much like that available to the B-52 radar navigator. This frees the AWADS nav from weather and visual ground reference constraints faced by the conventional C-130 navigator. The Ka-band radar, with a 7-inch IP-987 scope, allows the AWADS navigator to find and use targets unacquirable on the smaller IP-0268 scopes of conventionally equipped aircraft. Therefore, AWADS equipped aircraft can airdrop cargo or personnel even though they have no visual contact with the DZ.

Prior to flight, the AWADS navigator selects radar update targets along the low-level route. These might include a peninsula, a dam or bridge, or even a road intersection. The next step is to measure target coordinates and compute terrain altitude. This information is then programmed into the ASN-24 computer. En route, the navigator selects the appropriate target and commands the computer to display

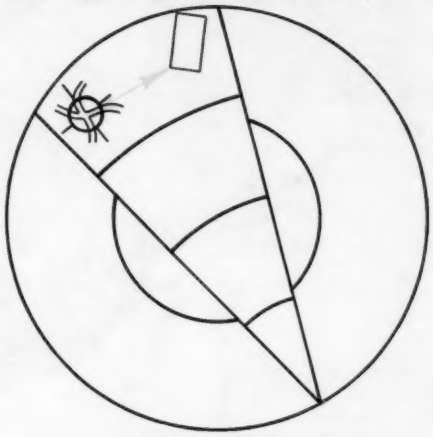


it on the radar scope. After evaluating placement of the crosshairs (radar cursor), the navigator either accepts the computer position or repositions the crosshairs to where he believes the target lies. The computer next measures the range and bearing to the crosshairs and triangulates a corrected computer position. This allows the AWADS navigator to stay on course without visual reference to the ground.



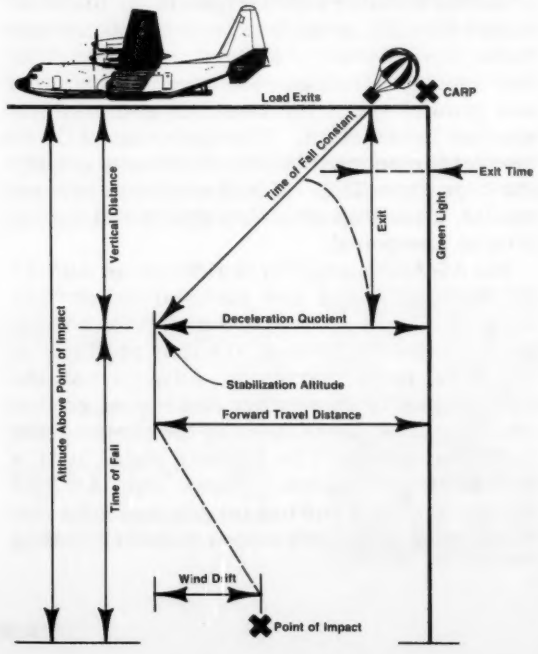
During preflight planning, AWADS navigators use intelligence information to select offset aim points (OAPs) for aligning the aircraft during final approach to the DZ. These OAPs are usually fairly close to the specific cargo's desired point of impact (PI). Their exact range and bearing to the PI is supplied by Intelligence personnel. The accuracy of the airdrop hinges upon the precision of this intelligence information.

Offset aimpoint (OAP) for drop zone run



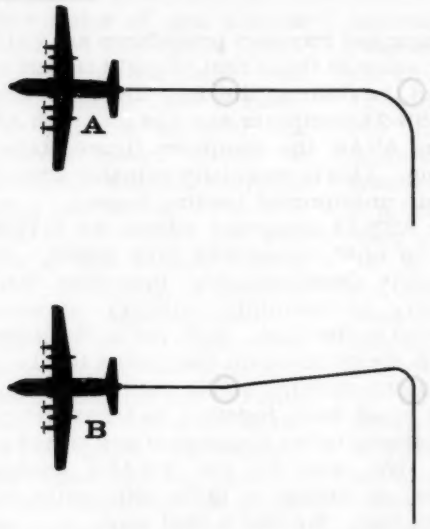
Just as bombers use wind and ballistic data to aim bombs, cargo aircraft employ the same information for aerial delivery of equipment, supplies and troops. Air density, temperature, parachute opening characteristics, absolute altitude, and average wind velocity are among the variables that determine how a load will exit the aircraft and drift during descent. These variables are evaluated and accounted for during preflight when the navigator calculates a

Components of the computed air release point (CARP) solution



computed air release point (CARP). The CARP solution yields a ground position over which the load must be released to impact on the PI. The CARP is initially computed with preflight "best guess" information. In-flight conditions usually differ from those predicted, so the navigator must correct the CARP solution right up to the instant when "GREEN LIGHT" is called and the load exits the aircraft. It is extremely difficult for a conventional C-130 navigator to instantly evaluate all the variables involved in an airdrop. AWADS navigators enjoy the luxury of a computer to monitor variables and continually update the CARP. This frees the navigator to devote more time to things that the computer can't monitor.

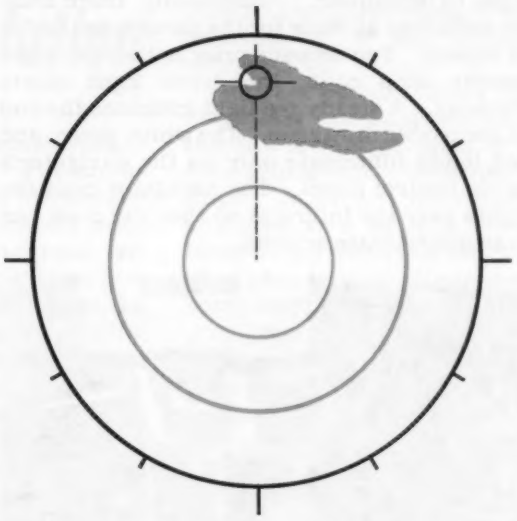
AWADS aircraft (A) turn short to roll out on centerline. Conventional C-130s (B) employ standard radius-of-turn procedures.



As the AWADS aircraft follows a low-level route, it tracks point-to-point. Usually, route control points are not coincident with ground reference targets—road intersections, dams, railroad crossings, etc. Thus AWADS routes can be planned away from potential threat areas such as AAA, GCI sites, SAM installations and inhabited areas where C-130 overflight might be detected. En route to each control point, the computer indicates distance to go and distance left or right of centerline (cross-track error). AWADS aircraft routinely turn short of checkpoints to roll out on centerline for succeeding legs.

Approximately 10 miles before the DZ, the AWADS navigator places the ASN-24 computer into the airdrop or DZ-up mode. Three OAPs can then be displayed as selected. After selecting the first OAP, the radar indicates where that target should appear on the scope. The computer again provides distance to go in miles, yards right or left of course, and seconds to go. These indications are relative to the CARP. The navigator must hold the radar crosshairs on the target to minimize the effect of computer drift—an inherent computer error.

En route radar navigation computer update



While the computer's present position is continually updated by crosshair adjustment and DR, the ASN-24 continually figures a real time CARP, based on preprogrammed information and data received through remote sensors. If the aircraft is 50 feet higher or 10 knots faster than desired, the CARP is automatically adjusted to compensate. Such accuracy would be difficult for a navigator computing corrections manually.

Inbound to the DZ, the navigator switches to the second OAP when the first is no longer usable or the second becomes more visible on the scope. If the DZ is marked by a beacon or the PI is otherwise identifiable on the scope, the navigator selects the third and final OAP for the drop. During the run-in the navigator must continually hold the radar crosshairs over the OAP.

Approaching the DZ, the navigator must keep the pilot advised of time to go, drift, and track information. Distance to go is displayed on the pilot's HSI. Track information is critical as it tells the pilot how much to alter the aircraft's heading for course correction. The final run is like an ARA to the DZ, without glideslope information.

Two minutes prior to the CARP, a white light illuminates on the ASN-24 mode control indicator. Ten seconds prior to the release point the white light flashes. At the release point, a green light illuminates. The aircraft must track within 10 degrees of drop zone heading and be within .6 miles of the CARP for the green light to illuminate. Additionally, there must be sufficient altitude for the parachutes to fully deploy. Ten seconds prior to the end of the usable drop zone, the green light starts flashing. A steady red light indicates the end of the usable drop zone. The white, green, and red lights illuminate only on the navigator's mode control panel. The navigator calls the lights over the intercom so that the crew can take appropriate actions.

On all AWADS drops, the navigator prebriefs the pilot and copilot on the expected run-in to the DZ and the expected CARP position. If weather permits, the pilots back-up the navigator visually and call a no-drop if the run-in and CARP differ significantly from what is prebriefed.

Escape and recovery procedures are virtually the same as those that brought the aircraft around the route to the drop zone. However, the ASN-24 computer can run a superb ARA. During ARAs, the computer figures time to landing. This is especially valuable when flying into unimproved landing zones.

The ASN-24 computer allows the C-130 to drop on unlit, unmarked drop zones. This capability immeasurably increases MAC's capacity to resupply military personnel deployed in the field. Still, AWADS-equipped aircraft are by no means the answer to all of the Air Force's tactical airlift needs. All C-130 forces must work together to transport men and material to the trenches of any armed conflict. We, who fly the AWADS equipped C-130s, do things a little differently than anyone else. We like it that way.

Lt Burton enlisted in the South Carolina ANG in 1977 and was assigned to McEntire ANG Base. He completed Reserve Officer Training at the University of South Carolina in 1981 and was then assigned to Pope AFB. Lt Burton now serves at Howard AFB.

Indian Ocean Enigma — The Solution

For those of you who've spent the past four months pondering the whereabouts of Lt Al T. Tude, we're pleased to offer the "school solution" to our Indian Ocean Enigma from the Spring '84 issue. To help locate Al, you were told that he is in the Indian Ocean, which narrows your focus to 28,350,000 square miles.

The first day Al made three observations of the Sun as it passed from his left to right, which places him north of the Sun's subpoint. Remember, these observations were on the day following his unfortunate ditching.

Since the Sun's altitude exceeded 85 degrees, Al's initial position can be resolved by the standard intercept method or by the quicker zenith-distance method. With the zenith-distance method, observations of bodies whose altitudes exceed 85 degrees or whose subpoints fall within 300 nm of the observer can be resolved to an LOP (circle of equal altitude) without HO 249 computations. Simply subtract the observed height from 90 degrees. For example, the first Ho of 86 degrees 12 minutes, subtracted from 90, yields 3 degrees 48 minutes, which converts to a zenith distance of 228 nm. To plot the LOP, you use the body's GHA and declination as a plotting position. Remember to subtract GHA from 360 to determine plotting longitude. With the position charted, you then scribe the circle of equal altitude with a 228 nm radius. Repeat this procedure for the remaining observations.

Using intercept procedures, you must select an assumed position, perhaps halfway between Diego Garcia and Johannesburg, South Africa, on a straight-line course. Then follow standard computations and refine the position until resultant intercepts are manageable.

These computations yield Al's ditching position: approximately 13°00' south latitude, 60°00' east longitude. To determine the bona fide island that he and his pals washed up on, you next need to address Al's second set of observations and that strange phenomenon of a darkening sky.

If you haven't already guessed, Al happened to be making those later observations during a solar eclipse. With an Air Almanac for Feb 1980, you could reference the date of that month's solar eclipse. Otherwise, assuming such conditions, a sky diagram confirms that Vega probably was the bright body midway up in the northwestern sky.

Intercept computations for those last two observations, the Sun and Vega, yield Al's final beachhead. Remember, Capt Allen's narrative specified that Al and crew landed on a bona fide island. That should have eliminated coral reefs and shoals from your consideration.

If you computed and plotted the Sun's and Vega's lines-of-position correctly, they intersect on or near the northern-most end of Coetivy Island, some 150 nm south of Mahe Island and the Seychelles VOR, in the Seychelles Islands. The approximate coordinates are 7°06' south latitude, 56°16' east longitude. You may have been tricked, at first, by the fact that our daring adventurers did not land on the island closest to their original ditching position. Also, literary liberties were taken with the distance our seafarers paddled their life raft.

All of this aside, we hope this enigma gave you cause to review seldom-used celestial procedures and to polish your navigator skills.

The First O

Captain Steve D. DOHERTY
7 BMW/DOC
Carswell AFB, TX

Bleckley, Kingsley, Truemper and Femoyer—a few aviators whose names live in military history as heroic navigator-observers and recipients of the Medal of Honor. But what about Dr Thaddeus Lowe and Mr John LaMountain? Why are their names somewhat obscure? In fact, just who were they?

Unless you are a Civil War enthusiast you probably are unfamiliar with these famous aviator-observers. Nevertheless, Dr Thaddeus Sobieski Coulincourt Lowe and John LaMountain are aviation legends of their own time. They were part of the United States Army's first attempt to establish an Aeronautical-Observation Corps. Oddly, in their day there were no airplanes. Instead, they flew hydrogen balloons. For a short time during the Civil War, from June 1861 through June 1863, the United States Army even had an air force, a reconnaissance program, and the nation's first observers—forerunners of today's navigators.

The Union Army Aeronautical-Observation Corps got its start on June 18, 1861, when aeronaut, meteorologist, and inventor Dr Thaddeus Lowe went aloft in the *Enterprise*, his giant 20,000 cubic foot balloon. On that day, the *Enterprise* ascended over 500 feet above the nation's capitol in the June sky. Beneath her cargo platform, a nearly invisible hair-thin wire, wrapped in green silk, stretched to the reel of a telegraph key station below. For the flight, the *Enterprise* carried a full set of signal apparatus. Shortly after his ascent, Lowe transmitted an historic message to President Lincoln. With this act, the modern observer was born. Lowe's message read:

> *Dear Sir,*
> *From this point of observation we command an extent of country nearly fifty miles in diameter. I have the pleasure of sending you this first telegram ever dispatched from an aerial station and acknowledging indebtedness to your encouragement for the opportunity of demonstrating the availability of the science of aeronautics in the service of the country. I am,*
> *Your Excellency's obedient servant,*
> *T.S.C. Lowe*

President Lincoln was so impressed by Dr Lowe's demonstration that, on 19 June 1861, he authorized the Secretary of War to form the Federal Balloon Corps. Lowe was named Commander-in-Chief. The Balloon Corps' mission was to provide observers and airships to spy on Confederate troop and supply movements.

The Balloon Corps' first reconnaissance flight lifted skyward on 31 July 1861, at Fort Monroe, Virginia. The balloonist-observer, John LaMountain, supporting forces under General Ben Butler, observed that Confederate camps surrounding the fort were not as threatening as previously suspected. John LaMountain thus became the first U.S. observer to fly a combat aerial reconnaissance mission.

LaMountain also piloted the first night aerial reconnaissance flight. Ingeniously, from his vantage point in the balloon, he estimated Confederate strength by counting tent lights within his viewing area. That tactic led to the first blackout for Confederate forces. From then on, camp lights were covered and dimmed whenever Union balloons operated in the area. The blackouts continued throughout the war.

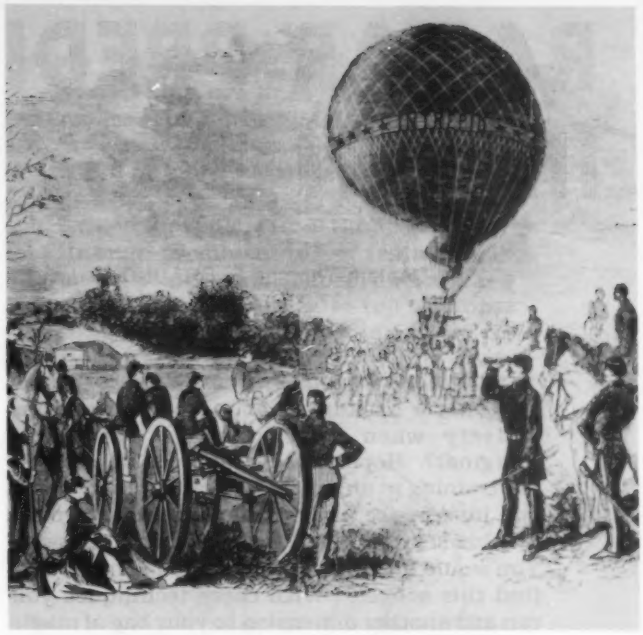
Dr Lowe and his aeronautical observers performed numerous reconnaissance missions during the war. One of the most important of those missions occurred during the siege of Richmond in May 1862. The balloons—*Intrepid*, *Washington*, and *Constitution*—were stationed at strategic locations around the town of Mechanicsville. On May 29, an observer in the balloon *Washington* noted unusual enemy activity opposite the Union troops' Gaines Mill positions. Confederate forces were concealing their activities in the trees on the southern bank of the Chickahominy river. The message Lowe transmitted to General McClellan would change McClellan's strategy. It read, "I have a feeling they may attack Heintzelman's isolated force." General Heintzelman and a small Union force had crossed the river and taken up positions on the southern bank of the Chickahominy. McClellan immediately sent a small group of reinforcements to Heintzelman and repositioned two full brigades closer to his own positions—a strategic move that affected the outcome of the entire battle.

bservers

On 31 May, from the *Washington*, Lowe observed troops and wagon trains streaming out of Richmond toward the center of Heintzelman's first line of defense. He also noted Confederate brigades, opposite Mechanicsville, on the march to join their comrades. Dr Lowe, now certain that the Confederates planned to attack General Heintzelman's small Union force, across the Chickahominy, decided to transfer to the *Intrepid*. (The larger airship could carry telegraph equipment high enough to observe the entire battlefield.) However, when he reached the mooring site, six miles away, the *Intrepid* was only partially inflated. Lowe was forced to settle on the smaller balloon, *Constitution*, for his observations. When he finally ordered the *Constitution* down, he transmitted details of the most important observation of his career. His message read:

> *Chief of Staff*
> *There are large bodies of troops in the open field beyond the opposite heights in the New Bridge Road. White-covered wagons are rapidly moving toward the point of the engagement with artillery in advance.*
>
> *T.S.C. Lowe*
> *Chief Aeronaut*

In the nick of time, McClellan ordered two of General Sumner's nearby divisions to reinforce Heintzelman's troops, already driven back to their second line of defense. As the battle raged throughout the day, Lowe continued sending reports from the now inflated *Intrepid*. Every 15 minutes his reports buzzed over the wires to the War Department in Washington, conveying the intensity and direction of the Confederate attacks and Union counterattacks. By day's end, blue and grey-clad soldiers lay dead and dying across the battlefield. The Confederates had thrown every available man at the Union forces, and had lost. Lowe's early report gave the Union forces time to entrench. He was the hero who saved the day! With Lowe's success, the tactical value of the airborne observer was fully proven.



Lowe's ascent in the Intrepid, near Vienna, Virginia.

Many similar episodes occurred through the short history of the Aeronautical-Observation Corps. An impressive record of service was established at famous battlefields such as Fair Oaks (May '62), Gains Mill (May '62), Fredericksberg (Dec '62), and Chancellorsville (May '63). However, in June of 1863, despite intense interest, the Aeronautical-Observation Corps was abolished. Official recognition of the balloonist-observer and the aerial reconnaissance mission would have to wait 50 years.

As for Dr Thaddeus Lowe and Mr John LaMountain, their contributions to aerial reconnaissance and the observer profession remain with us today. Besides being the first Commander-in-Chief of the Aeronautical Corps, Dr Lowe pioneered such tactics as airborne artillery fire control, aerial photography, and aerial bombardment. Together with his compatriots, Dr Lowe endowed aviators with a new profession that would endure for generations—the navigator-observer.

A graduate of Southwest Texas State University, Capt Doherty completed UNT in 1974. After CCTS at Castle AFB, he was assigned to Minot AFB in the KC-135. In 1978, he was reassigned to Mather AFB, where he also obtained a Master of Science degree in 1981. Capt Doherty now serves at Carswell AFB.

RADAR PREDICTING IN TEN EASY STEPS

Captain Thomas F. BRAUND
27 TFW/DOR
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How many weapon systems officers (WSOs) plan a backup radar target for weapons delivery when forecast range weather is marginal? Hopefully, everyone. Suppose you are training at an unfamiliar range where bomb run inserts are unavailable and radar predictors are scarce. What would you do? Answer: You would dig into your bottom file drawer and find this article. With these techniques you can add another dimension to your bag of magic tricks—one that may someday pay you dividends.

While drawing any target prediction remember the basic characteristics of reflected radar energy. Can you use your knowledge of radar shadows, no-shows and cultural feature returns, and inherent radar errors to forecast how targets will look on your scope? Low-altitude operations generally produce longer radar shadows which can mask some returns.

For instance, a 10 ft obstacle at 10 nm casts a 1,480 ft shadow for an aircraft at 500 ft AGL. Low-altitude flight produces sharper contrasts in your radar picture. Be cautious of cultural returns that may not show exactly as depicted on your chart. Differences result from cardinal effects, line-of-communication build-ups, etc. Drawing radar predictions may seem an overwhelming task at first, but you'll learn quickly with the following basic steps.

STEP 1. LOCATE MATERIALS

a. Current charts:
1:250,000 JOG-As or JOG-Rs; 1:200,000 ATCs work best for general planning.
b. Photos of target area, if available.
c. Fightergator tools—Weems plotter, compass, colored pencils, tracing paper, sandpaper, scope grid template and calculator (both optional).

STEP 2. DETERMINE PREDICTION AREA ON YOUR CHART

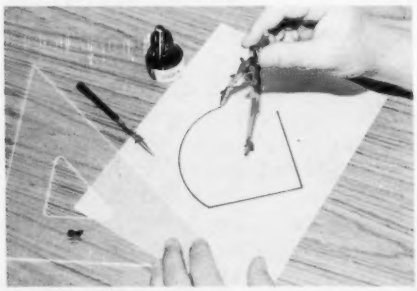
a. Obtain target coordinates and description, attack heading, and altitude.
b. Determine maximum radar ranging based on aircraft altitude.

$R_r = \sqrt{1.5 \times AA\ (ft)}$

R_r = radar range
AA = aircraft altitude

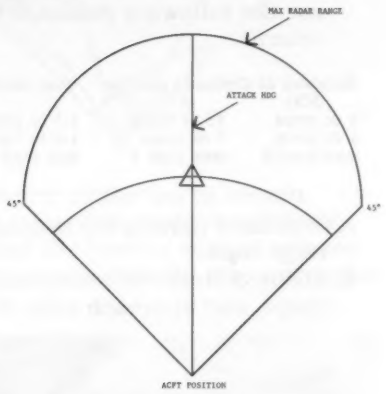
ACFT ALT (ft)	RANGE (nm)
100	12.2
200	17.3
500	27.4
1,000	38.7
2,000	54.8
5,000	86.6
10,000	122.5

c. Draw a radar scope grid of appropriate size for R_r. Templates can be made for different scale charts.



d. Center the target area and key features inside the template, ½ to ⅔ distance from the scope vertex.
e. Draw the attack-heading line from the vertex through the target to top of scope.

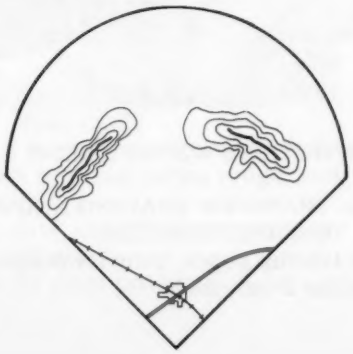
f. Look for probable offset targets, significant contours, cultural clusters and areas that might be lost in shadow.



STEP 3. LOCATE RIDGE LINES

a. Find ridge crests. You may have to interpolate between contours for the crest elevation. (Crests are where shadows begin.)

b. Draw a heavy black line along the length of crests for both large and small terrain features.

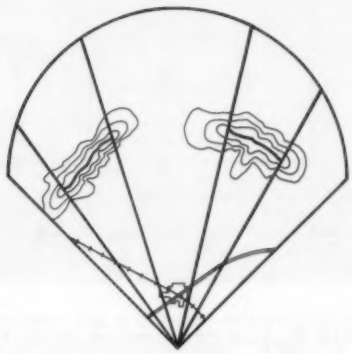


STEP 4. DRAW RADIAL LINES

a. Radials simulate lines of energy from the radar. For F-111 WSOs, I recommend drawing radials every 4° (F-111 beam width is 1.6°). More radials produce greater detail.

b. Extend the radials from the scope's vertex through prominent target features, i.e., major peaks, saddlebacks, and marked elevation differentials, to top of scope.

c. Draw radials tangent to the ends of the ridge lines. This will help define shadow displacement and shape.



STEP 5. DETERMINE SHADOW LENGTHS

a. The best way to predict terrain shadowing is through earth cross-sectional analysis (See Fig 1).

b. Check each radial for radar energy obstructions along the ridge fronts. Start in areas of close contouring and work toward top of scope.

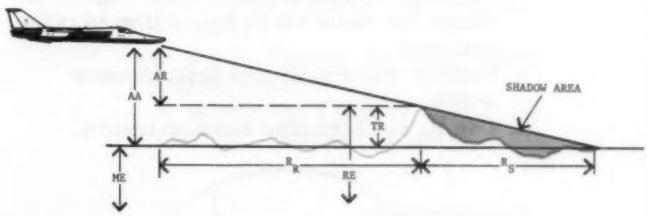


Figure 1

c. To determine shadow length, first compute terrain rise (TR) and altitude above the radar return (AR). Terrain rise (TR) = radar return elevation (RE) – mean terrain elevation (ME); altitude above radar return (AR) = aircraft altitude (AA) – radar return elevation (RE).

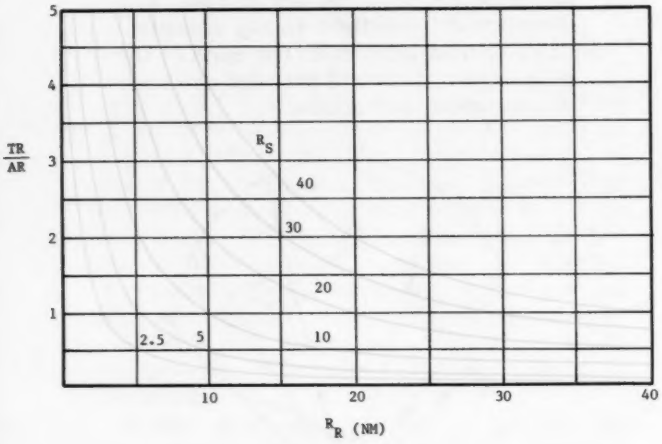
d. Use the following equation to find shadow length (R_S).

$$R_s = R_r \times \frac{TR}{AR}$$

Example: ME = 4,000' RE = 5,000' AA = 6,000' R_r = 15nm

MSL TR = RE — ME = 1,000'
MSL AR = AA — RE = 1,000'

$$R_s = 15 \times \frac{1,000'}{1,000'} = 15nm$$



e. With R_S you can predict areas that will show and those that will be lost in shadow.

f. If you have time, vary R_r to determine where OAPs or targets will appear out of shadows. This could be critical to mission success.

STEP 6. DEPICT SHADOW AREAS

a. Use a bright color to shade predicted shadows.

b. Starting at peaks and centers of ridge lines, shape the shadows in proportion to ridge contours.

c. Radials will define and limit shadow width.

d. Use R_S to determine shadow length.

STEP 7. ANALYZE HIGHLY REFELECTIVE AREAS & CULTURAL FEATURES

a. The steeper the terrain the more reflected energy returned to the radar antenna (radar grazing angle concept).

b. Determine rise gradients by noting contour packing. On a JOG with 200 ft contour intervals or an ATC with 100 ft intervals, use the following guidance to shade returns.

Numbers of Contours per nm		Rise Gradient	Shading
JOG	ATC		
8 or more	15 or more	1:4 or greater	heavy
4 or more	7 or more	1:8 to 1:4	moderate
less than 4	less than 7	less than 1:8	light

c. Gradually darken the shading toward the ridge tops.

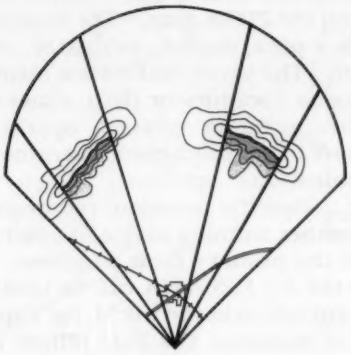
d. Shade cultural returns to match type, shape, and approach axis.

STEP 8. OUTLINE WATER AREAS

STEP 9. TRANSFER SHADING AND ADD GROUND CLUTTER

a. On tracing paper, transfer scope grid outline from chart.

b. With a compass, trace highly reflective returns in dense black, preferably ink. Use arcing motions swung from the scope's vertex.
c. For bodies of water, emphasize far banks with darker shading.
d. Add ground clutter to all other areas except shadows. The steeper or rockier the terrain, the more prominent the clutter.
e. Use course sandpaper under the tracing paper to draw clutter.



f. Shade ground clutter up to terrain shadows. Outline shadows diffusely.
g. Insure that the leading edge of returns is shaded more intensely than surrounding areas.

STEP 10. LABEL YOUR PREDICTION, EDIT, AND COPY

a. Label the target, offset aim points, attack heading, scope range, and altitude.
b. Add date, classification and your identification.
c. Edit for final product.

d. Reproduce on a copier, adjusting intensity for maximum detail. Place a sheet of white paper behind the tracing paper for best results.

Are you bold enough now to use your finished product? Go ahead and give your predictions a try. You may be surprised with your improved radar navigation accuracy and the self-satisfaction derived from your effort.

References: 1. TACM 200-2, Radar Prediction and Associated Intelligence Support.
2. F-111 Fighter Weapons School Digest, Vol 2, No 1.
3. Advanced Tactical Radar Prediction Course, Lowry AFB.

Capt Braund graduated from the University of Wisconsin in 1970 with a degree in Meteorology. After UNT and initial F-4 training, he served at Osan AB in 1974, followed by duty at Eglin AFB. Capt Braund served subsequent tours in the F-111 at Mt Home AFB and RAF Upper Heyford before his current duty at Cannon AFB.

they call me "ARIA"

Captain Donald K. MEYER
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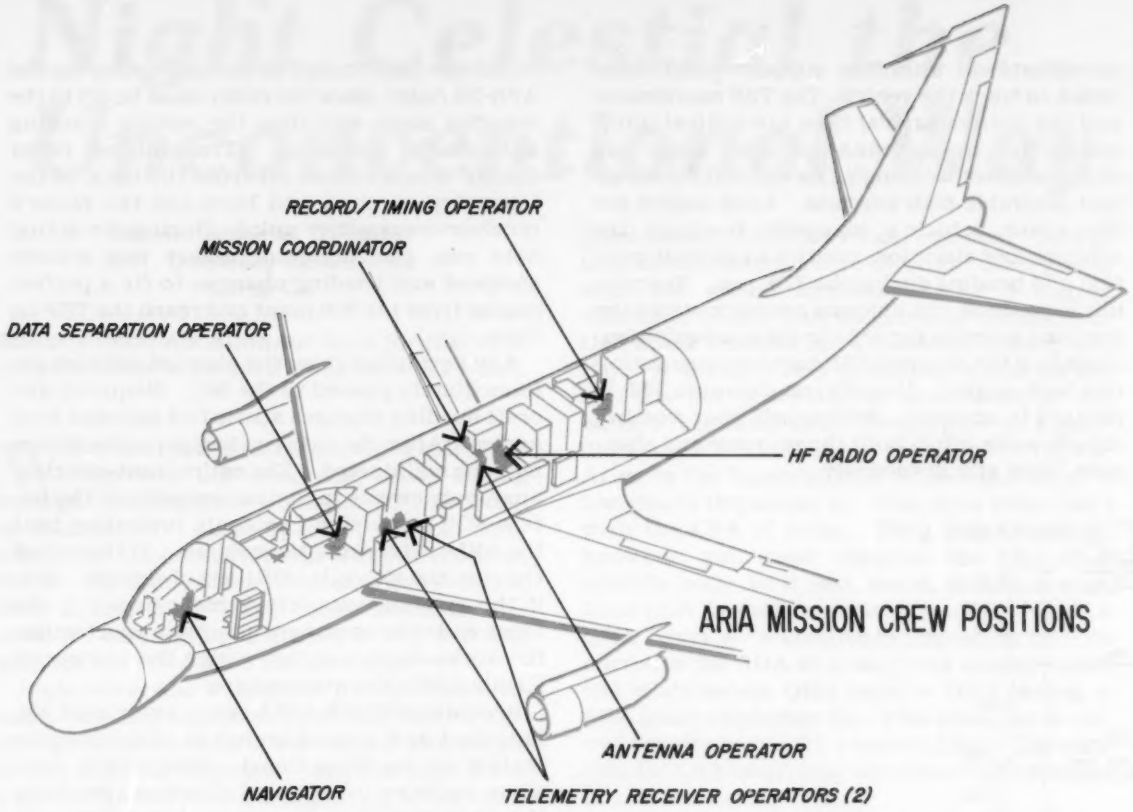
Wright-Patterson AFB, OH

Since the first C-135 airframe rolled off the assembly line almost three decades ago, the basic design has undergone many unusual modifications. One of the most unique variations, except for possibly the E-3A Sentry (AWACS) model, is the EC-135 ARIA, or Advanced Range Instrumented Aircraft. Wright-Patterson AFB is the home of the five snout-nosed ARIA flown by the 4950th Test Wing (AFSC). The original ARIA was designed to support NASA's 1960s Apollo program, providing a tracking and communications network for the Apollo lunar missions. Future plans call for the current ARIA airframes to be replaced by Boeing 707s purchased from the airlines. The 707 airframe is slightly larger than the C-135 airframe. When the transition is complete, these seven new ARIA will be designated EC-18s.

Most of the ARIA fleet is powered by TF-33 turbofan engines with reverse thrust capability, but one aircraft is still equipped with the older J-57 "waterwagon" engines. Besides the enlarged nose radome, several other external features separate the ARIA from other C-135 models. A 130-foot trailing wire antenna is installed on the bottom center of the fuselage and two additional probe antennas sit atop the wing tips. A VHF data dump blade antenna is located on the bottom of the fuselage while a tactical satellite antenna is on top. The Prime Mission Electronic Equipment (PMEE) is in the back of the aircraft. It is used to track spacecraft or missiles; receive, record, and retransmit telemetry data; and link communications between aircraft and spacecraft as well as between aircraft and ground or surface stations. The fully instrumented aircraft can track and communicate with spacecraft and missiles from launch through staging, ballistic flight or orbital insertion, and re-entry.

A normal ARIA flight crew consists of eleven crew members--four in the cockpit and seven operating the PMEE gear. The front-end crew includes a pilot, copilot, navigator, and flight engineer. The seven PMEE crew members are the mission coordinator (MC), timer-recorder operator, antenna control operator, two spacecraft communications operators, an HF communications operator, and a systems analyst. Specific mission requirements or crew member training may add others to supplement the primary crew positions.

Since the EC-135 ARIA can be tasked to fly almost anywhere in the world, for support of a variety of missions, the FLIP (Flight Information Publication) becomes the ARIA navigator's best friend. The ARIA is well equipped with navigation aids. An inertial navigation/Doppler navigation system (INS/DNS) is standard



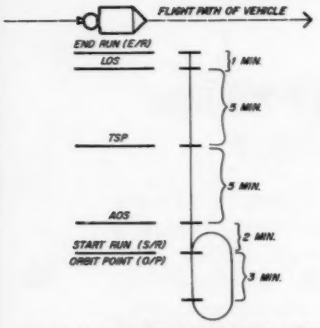
on all ARIA as is an AN/ARN-131 Omega navigation system. Two ADFs and an APN-59 radar, with the iso-echo feature, complete the list of navigation avionics available to the ARIA navigator. Since support missions fly over vast ocean areas, celestial navigation is practiced to crosscheck accuracy of the INS/DNS and Omega positions.

On a support mission, the ARIA navigator's most important task is positioning the aircraft at a test support point (TSP) at a specific launch-plus-time (T+), with a tolerance of only seconds. To do this, the navigator plans to arrive at a predetermined geographical point called the start run (S/R) point, usually 40 to 80 nm from the TSP, on a reciprocal heading from the required run heading. The run distance is determined by the amount of time necessary to track the vehicle and obtain required data versus the groundspeed of the aircraft. If the space vehicle is being launched into orbit, the ARIA support altitude is usually between FL 300 and FL 350, with a planned groundspeed of 420 knots. If the vehicle is a ballistic missile, it is planned to impact 20 nm in front of the ARIA at the TSP. Just prior to vehicle launch, the ARIA descends to 15,000 feet to improve telemetry data acquisition during the final seconds before vehicle impact. At this altitude, the planned groundspeed is usually 360 knots.

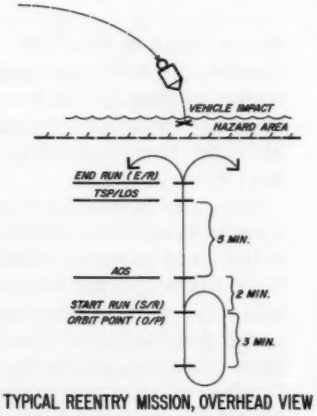
Once the aircraft arrives at the S/R point on a support mission, a racetrack holding pattern is initiated to await vehicle launch or re-entry. Each holding orbit normally is planned for 12 minutes, with a one-degree-per-second bank angle producing a three-minute, 180 degree turn. Thence, we fly three minutes outbound. Timing charts and graphs are employed to adjust the outbound leg distance for arrival at the TSP at the controlled time. Although this may sound simple in theory, strong crosswinds or head/tail winds can make precise orbit timing quite sporting, to say nothing of decending 15,000 to 20,000 feet in the final turn, with the true airspeed, wind, and bank angle constantly changing.

If excessive headwinds, weather, a delayed takeoff, or other problems make it impossible to arrive at the TSP on time, the navigator must

coordinate an alternate support point from which to track the vehicle. The TSP coordinates and the correct arrival time are critical information for the antenna operator, since any changes affect look angles for the ARIA's seven-foot steerable dish antenna. Look angles are the space vehicle's magnetic bearings for azimuth and elevation, relative to aircraft position and heading during the TSP run. From an initial position, the antenna operator steers the tracking antenna for vehicle signal acquisition. Changing the planned TSP requires computing new look angles. Usually, an alternate TSP is planned in advance. Seldom will poor weather significantly affect both the primary and alternate TSPs simultaneously.



TYPICAL ORBITAL MISSION, OVERHEAD VIEW



TYPICAL REENTRY MISSION, OVERHEAD VIEW

Another variable that figures into the ARIA navigator's timing at the S/R point is a "hold" in the vehicle launch schedule. If the launch is held after the ARIA is on station, we reduce airspeed to maximize on-station time. After the launch count is resumed, the navigator corrects orbit timing computations and again steers the ARIA toward the TSP. This juncture offers the last chance to check weather on the APN-59 radar, since the radar must be set to the standby mode any time the vehicle tracking antenna is operated. (Transmitted radar energy would reflect off from the back of the telemetry antenna and burn out the radar's receiver-transmitter unit.) During the actual data run, the navigator makes last minute airspeed and heading changes to fly a perfect course from the S/R point and reach the TSP on time.

Any deviations from the planned mission are immediately passed to the MC. Required aircraft heading changes also affect antenna look angles. After the data run begins, radio silence must be maintained. The entire front-end crew anxiously awaits radio transmission of the letters AOS (acquision of signal), indicating that the ARIA is tracking the vehicle. At the end of the run, the MC calls LOS (loss of signal). But, if the mission supports vehicle re-entry, the front-end crew members glimpse a spectacular fireworks display as they watch the spacecraft flaming into the atmosphere.

Recently, 4950th ARIA crews supported air-launched and ground-launched cruise missile testing on the West Coast. Frequently, missions are flown to support Trident and Pershing II test firings as well as communications and weather satellite launches. Perhaps the most interesting vehicle the ARIA supports is the space shuttle. Not only do ARIA crews track booster rocket separation during certain shuttle launches, but we also have tracked satellites launched from the shuttle's cargo bay.

The demands on the ARIA navigator are often varied and always challenging, but the satisfaction gained from a successful orbital or re-entry mission makes the effort worthwhile. With more and more space vehicle launches occurring each year, the ARIA navigator can count on many challenging missions in the years to come.

Commissioned through OTS in 1974, Capt Meyer graduated from North Texas State University. He completed UNT in 1975 and then served in the EC-135 at Grissom AFB. Assigned to Wright-Patterson AFB since 1981, Capt Meyer now is a Flying Safety Officer for the 4950th Test Wing.

Night Celestial the Unconventional Way

Captain James M. DORMAN
AFIT, University of California
Davis, CA

Editor's Note: Air Almanac data for this article was extracted from the Jul - Dec '82 issue.

When is night celestial not night celestial? When you are observing stars during daylight conditions or when the HO 249, Vol I, is unavailable. To be specific, you can complete star fix computations without HO 249, Vol I. The alternate method employs HO 249, Vols II and III. These books normally are used for calculating altitudes of the Sun and planets but they have broader use.

Sight reduction Vols II and III, you recall, require entering arguments of Local Hour Angle (LHA) and declination of the body, if declination is less than 30 degrees. Consider page F4 of your Air Almanac, at the beginning of the white pages, behind the Navigational Star Chart (Fig 1). This index lists 57 navigational stars in ascending numerical order corresponding to the decreasing order of each star's Sidereal Hour Angle (SHA). The declination of each star is also given. If we know the SHA of a body, we can easily determine its LHA. What about declination? The small note at the bottom of the index, annotated by the cross symbol (†), provides the answer. Each star so annotated has a declination of less than 30 degrees and, therefore, may be used with Vols II and III.

Now that we know the stars available for use with Vols II and III, let's consider the computations. Determining the star's LHA from its SHA is the primary difference between Vol II and III solutions and normal Sun or planet computations. It might be helpful to briefly review the relationship of SHA and LHA (See AFM 51-40, Chapter 11).

Recall that a body's SHA is the angular distance measured westward from the hour circle of Aries to the hour circle containing the subpoint of the body. The first point of Aries is the point where the Sun appears to cross the celestial equator from south to north. This point is also called the vernal equinox. SHA is then measured from zero through 360 degrees, with the vernal equinox as the 0 degree reference point. An interesting sidelight is that a star's SHA is not a constant, fixed quantity. It changes very gradually, about 50 arc seconds per year, due to precession of the earth's rotational axis. Recall that for a standard star observation you compute the LHA of Aries by the formula: LHA = GHA (Aries) $\pm$ $^{E}_{W}$ Longitude (Equation 1). You then enter Vol I with the LHA of Aries. With Vols II and III, however, you must compute the LHA of a specific body, be it Sun, moon, planet or star. Your LHA formula now becomes: LHA (star) = GHA (star) $\pm$ $^{E}_{W}$ Longitude (Equation 2). To compute the GHA of a star, you merely recall the relationship: GHA (star) = GHA (Aries) $\pm$ SHA (star) (Equation 3). This equation is correct for any body with a known SHA. The solution for LHA (star) may therefore be expressed in column notation as:

LHA (star) = GHA (Aries)
+ SHA (star)
– 360 degrees (if required)
+ E
– W Longitude (Equation 4)

F4 INTERPOLATION OF MOONRISE, MOONSET

FOR LONGITUDE

Add if longitude *west*
Subtract if longitude *east*

Longitude	Diff.* 05	10	15	20	25	30
°	m	m	m	m	m	m
0	00	00	00	00	00	00
20	01	01	02	02	03	03
40	01	02	03	04	06	07
60	02	03	05	07	08	10
80	02	04	07	09	11	13
100	03	06	08	11	14	17
120	03	07	10	13	17	20
140	04	08	12	16	19	23
160	04	09	13	18	22	27
180	05	10	15	20	25	30

Longitude	Diff.* 35	40	45	50	55	60
°	m	m	m	m	m	m
0	00	00	00	00	00	00
[illegible]	03	03	04	04	05	05
[illegible]	[illegible]	07	08	08	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	11	12	[illegible]	[illegible]
90	[illegible]	[illegible]	[illegible]	[illegible]	42	45
100	36	39	[illegible]	44	47	50
110	40	43	46	49	52	55
120	43	47	50	53	57	60
130	47	51	54	58	61	65
140	51	54	58	62	66	70
150	54	58	62	67	71	75
160	58	62	67	71	76	80
170	61	66	71	76	80	85
180	65	70	75	80	85	90

* When negative *subtract* correction if longitude *west*, and *add* if *east*.

STAR INDEX, JULY—DEC., 1982

No.	Name	Mag.	S.H.A.	Dec.
			° ′	° ′
1*	*Alpheratz* †	2·2	358 08	N. 29 00
2	*Ankaa*	2·4	353 39	S. 42 24
3*	*Schedar*	2·5	350 07	N. 56 27
4*	*Diphda* †	2·2	349 19	S. 18 05
5*	*Achernar*	0·6	335 44	S. 57 19
6*	*Hamal* †	2·2	328 27	N. 23 23
7*	*Acamar*	3·1	315 36	S. 40 22
8*	*Menkar* †	2·8	314 39	N. 4 01
9*	*Mirfak*	1·9	309 14	N. 49 48
10*	*Aldebaran* †	1·1	291 16	N. 16 29
11*	*Rigel* †	0·3	281 35	S. 8 13
12*	*Capella*	0·2	281 09	N. 45 59
13	*Bellatrix* †	1·7	278 57	N. 6 20
14	*Elnath* †	1·8	278 42	N. 28 36
15	*Alnilam* †	1·8	276 10	S. 1 13
16*	*Betelgeuse* †	0·1-1·2	271 27	N. 7 24
17*	*Canopus*	−0·9	264 07	S. 52 41
18*	*Sirius* †	−1·6	258 54	S. 16 41
19	*Adhara* †	1·6	255 31	S. 28 57
20*	*Procyon* †	0·5	245 24	N. 5 16
21*	*Pollux* †	1·2	243 56	N. [illegible]
22	*Avior*	[illegible]	[illegible]	[illegible]
[illegible]	*Suhail*	[illegible]	[illegible]	S. 37 06
[illegible]	[illegible]	[illegible]	2·1	96 28	N. 12 34
47	*Ellanin*	2·4	90 57	N. 51 30
48	*Kaus Australis*	2·0	84 15	S. 34 24
49*	*Vega*	0·1	80 55	N. 38 46
50*	*Nunki* †	2·1	76 27	S. 26 19
51*	*Altair* †	0·9	62 31	N. 8 49
52*	*Peacock*	2·1	53 56	S. 56 45
53*	*Deneb*	1·3	49 47	N. 45 13
54*	*Enif* †	2·5	34 10	N. 9 48
55	*Al Na'ir*	2·2	28 13	S. 47 03
56*	*Fomalhaut* †	1·3	15 50	S. 29 43
57	*Markab* †	2·6	14 02	N. 15 07

* Stars used in H.O. 249 (A.P. 3270) Vol. 1.
† Stars that may be used with Vols. 2 and 3.

Figure 1

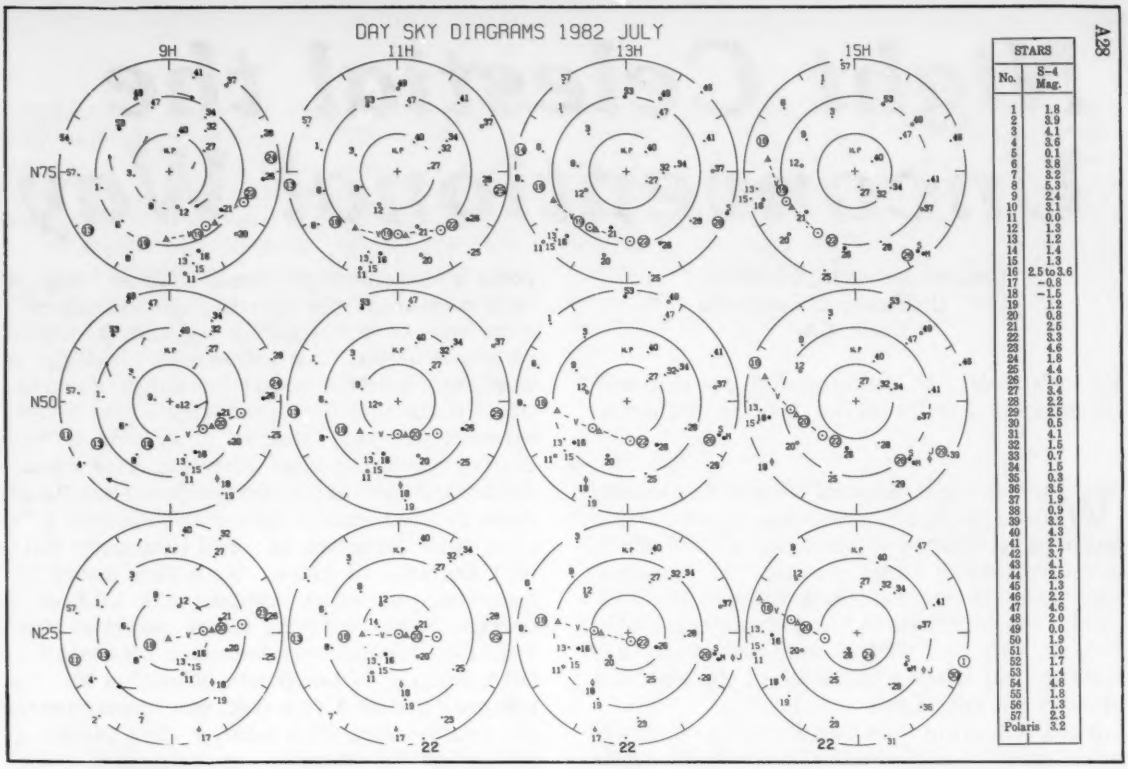


Figure 2

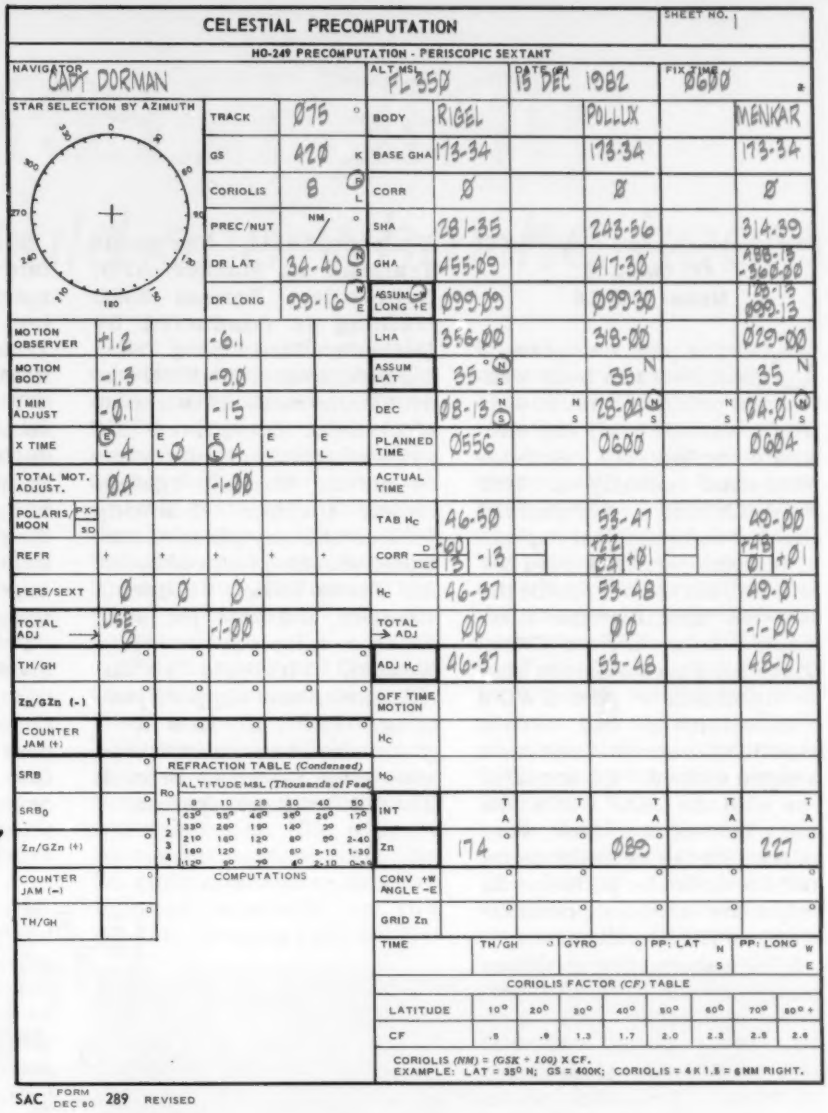
Using the solution from Equation 4 and the declination of the star in question, you can complete a precomputation from either Vol II or III. Corrections for motions, refraction, and Coriolis/rhumbline are applied as usual. Remember that precession and nutation (P/N) corrections don't apply to these celestial solutions. P/N corrections only apply to solutions from Vol I.

With an understanding of Vols II and III star solutions, let's consider some practical applications of this method. You can use this procedure anytime you wish to shoot a star not listed in Vol I. For example, you may desire to shoot a bright star during daylight or twilight conditions for a fix with a Sun, moon or planet LOP. Or, you might want to shoot only course lines or speed lines for which stars listed in Vol I are inappropriate. Also, you could be forced to select specific stars unobscured by weather. In any of these cases, you could plan your fix using Vol II or III stars.

During mission planning, consult sky diagrams that apply for the approximate positions and times of your celestial observations (Fig 2). With the diagrams you can select the most useful stars. Remember that bearings

Star No.	Name	MAG	SHA	Dec
1	Alpheratz	2.2	358-08	N29-00
4	Diphda	2.2	349-19	S18-05
6	Hamal	2.2	328-27	N23-23
8	Menkar	2.8	314-39	N04-01
10	Aldebaran	1.1	291-16	N16-29
11	Rigel	0.3	281-35	S08-13
13	Bellatrix	1.7	278-57	N06-20
14	Elnath	1.8	278-42	N28-36
15	Alnilam	1.8	276-10	S01-13
16	Betelgeuse	0.1 1.0	271-27	N07-24
18	Sirius	-1.6	258-54	S16-41
19	Adhara	1.6	255-31	528-57
20	Procyon	0.5	245.24	N05-16
21	Pollux	1.2	243-45	N28-04
25	Alphard	2.2	218-19	S08-35
26	Regulus	1.3	208-09	N12-03
28	Denebola	2.2	182-58	N14-40
29	Gienah	2.8	176-17	S17-27
33	Spica	1.2	158-56	S11-04
37	Arcturus	0.2	146-17	N19-17
39	Zuben' ubi	2.9	137-32	S15-58
41	Alphecca	2.3	126-31	N26-47
42	Antares	1.2	112-55	S26-24
44	Sabik	2.6	102-40	S15-42
46	Rasalhague	2.1	096-28	N12-34
50	Nunki	2.1	076-27	S26-19
51	Altair	0.9	062-31	N08-49
54	Enif	2.5	034-10	N09-48
56	Fomalhaut	1.3	015-50	S29-43
57	Markab	2.6	014-02	N15-07

Figure 3



CELESTIAL PRECOMPUTATION

SHEET NO. 1

HO-249 PRECOMPUTATION - PERISCOPIC SEXTANT

NAVIGATOR CAPT DORMAN | ALT MSL FL 350 | DATE (GMT) 15 DEC 1982 | FIX TIME 0600 Z

STAR SELECTION BY AZIMUTH

TRACK	075 °	BODY	RIGEL	POLLUX	MENKAR
GS	420 K	BASE GHA	173-34	173-34	173-34
CORIOLIS	8 (R/L)	CORR	0	0	0
PREC/NUT	NM / °	SHA	281-35	243-56	314-39
DR LAT	34-40 (N/S)	GHA	455-09	417-30	488-13 -360-00
DR LONG	099-16 (W/E)	ASSUM LONG +E	099.09	099-30	128-13 099.13
MOTION OBSERVER	+1.2	-6.1	LHA	356-00	318-00	029-00
MOTION BODY	-1.3	-9.0	ASSUM LAT	35 ° (N/S)	35 N	35 N
1 MIN ADJUST	-0.1	-15	DEC	08-13 (N/S)	28-02 (N/S)	04-01 (N/S)
X TIME	(E) L 4	E L 0	(E) L 4	E L	E L	PLANNED TIME	0556	0600	0604
TOTAL MOT. ADJUST.	04	-1-00	ACTUAL TIME			
POLARIS/SUN/MOON	PX / SD	TAB Hc	46-50	53-47	49-00
REFR	+	+	+	+	+	CORR D / DEC	00 / 13 -13	+22 / 22 +01	+28 / 01 +01
PERS/SEXT	0	0	0	Hc	46-37	53-48	49-01
TOTAL ADJ → USE	0	-1-00	TOTAL → ADJ	00	00	-1-00
TH/GH	°	°	°	°	°	ADJ Hc	46-37	53-48	48-01
Zn/GZn (-)	°	°	°	°	°	OFF TIME MOTION			
COUNTER JAM (+)	°	°	°	°	°	Hc			
SRB	°	Ho			
SRB0	°	INT	T A	T A	T A	T A	T A
Zn/GZn (+)	°	Zn	174 °	°	089 °	°	227 °
COUNTER JAM (-)	°	CONV +W ANGLE -E	°	°	°	°	°
TH/GH	°	GRID Zn	°	°	°	°	°

REFRACTION TABLE (Condensed)

Ro	ALTITUDE MSL (Thousands of Feet) 0	10	20	30	40	50
1	63°	55°	46°	38°	29°	17°
2	33°	26°	19°	14°	9°	6°
3	21°	16°	12°	8°	6°	2-40
4	16°	12°	8°	6°	3-10	1-30
	12°	9°	7°	4°	2-10	0-55

COMPUTATIONS

TIME | TH/GH ° | GYRO ° | PP: LAT N/S | PP: LONG W/E

CORIOLIS FACTOR (CF) TABLE

LATITUDE	10°	20°	30°	40°	50°	60°	70°	80° +
CF	.5	.9	1.3	1.7	2.0	2.3	2.5	2.6

CORIOLIS (NM) = (GSK ÷ 100) X CF.
EXAMPLE: LAT = 35° N; GS = 400K; CORIOLIS = 4 K 1.5 = 6 NM RIGHT.

SAC FORM DEC 80 289 REVISED

Figure 4

measured from the center of the sky diagram circle are the body's true bearings. The identification numbers of stars appearing in the sky diagrams correspond to those in Fig 1. Fig 3 identifies only those stars usable with Vols II and III. The SHA and declination in Fig 3 are also extracted from Fig 1. After selecting the star you plan to observe, you can complete necessary computations with simple math. (See sample precomp, Fig 4).

This method is a bit more cumbersome than computations used with Vol I; however, in some instances Vol II and III precomputations are very useful. They allow a larger choice of stars to shoot than those available from Vol I. This extra navigational tool could be your salvation, especially at FL390 when you ask over the interphone, "Has anyone seen the red celestial book since takeoff?"

Capt Dorman earned a degree in Physics and an ROTC commission at Louisiana State University in 1977. After completing UNT and CCTS, he served in the KC-135 at Altus AFB. Capt Dorman is now completing a master's degree in Physics at the University of California, Davis.

THE ELECTRONIC

First Lieutenant Louis J. MARTUCCI
441 BMS/CCE
Mather AFB, CA

Over the past few years, a great deal has been written and published about electronic warfare (EW) and electronic combat (EC). Articles published recently in THE NAVIGATOR adequately covered technological aspects of systems carried aboard EW aircraft, but did not profile the systems operator—the Electronic Warfare Officer (EWO). Other Air Force aviators may be uncertain of the EWO's responsibilities and duties, especially outside their own weapon system. I'll acquaint you with the USAF EWO; how and where he is trained, what aircraft he can be assigned to, and the duties he performs on respective electronic countermeasure (ECM) platforms.

EWO's share crew positions on eight specific aircraft types. These weapon systems represent every major command and every type of airborne platform. We think of an Electronic Warfare Officer as someone who listens to beeps and buzzes and employs electronic transmitters to interfere with and jam the enemy's electronic transmissions. Basically, that is true. However, specific EWO roles support a wide variety of duties and missions.

Electronic Warfare Officers are grouped within the navigator personnel utilization field. All EWOs wear navigator wings, earned after successfully completing Undergraduate Navigator Training at Mather AFB, California. Formal EWO training is conducted by Mather's 453rd Flying Training Squadron. The EWO student learns methods to employ electronic, deceptive, and pyrotechnic countermeasures to defend aircraft against enemy threats. Training focuses on every phase of electronic warfare practiced by the Air Force today. Students simulate and test for such diverse missions as Wild Weasel, strategic reconnaissance, and support jamming. Thus, the new EWO graduates with a working knowledge of duties in each USAF EW weapon system.

From basic electronic warfare school, EWOs proceed to specific weapon system training, either at a Combat Crew Training School (CCTS) or a Replacement Training Unit (RTU). There, EWOs learn mission requirements and duties for specific aircraft. From the beginning of UNT until the EWO is a mission-ready crew member takes approximately 1½ to 2 years, depending upon aircraft assignment.

Principle EWO roles can be divided into three broad areas: self protection, support, and reconnaissance. Perhaps the best known electronic warfare role is self protection—defending the aircraft by

WARFARE OFFICER:

if you could see what he hears

countering threatening airborne, shipborne or ground radar and missiles. The self-defense EWO uses a variety of countermeasures, ranging from electronic warning receivers to repeaters and powerful transmitters, to deceive or deny the effective use of enemy radar and communication systems. Expendables such as chaff and flares also are employed to elude enemy defenses. Since an aircraft may encounter a heavy threat environment in wartime, the EWO's correct and timely employment of electronic countermeasures (ECM) can be crucial to mission success.

EWOs perform the self-protection role in the B-52 and eventually the B-1 strategic heavy bombers. Self protection is also the EW's task on the MC-130, which supports special tactical missions such as infiltration and exfiltration of special operations and aerial reconnaissance, and the AC-130 close air support gunship. *(See Fury in the Spice Islands—A Navigator's Mission, page 5, this issue.)*

The EWO support role can encompass several different activities. Electronic support may involve aggressive suppression of enemy radar or large-area tactical radar jamming. Support/suppression missions employ the F-4G Wild Weasel, EF-111 and EC-130 Compass Call aircraft.

The Wild Weasel's specific mission is suppressing hostile radar-guided weapons. These EWOs employ electronic receivers to locate specific high-priority threats and counter them with antiradiation missiles. Often Wild Weasels achieve success through intimidation rather than active target suppression.

EF-111 and EC-130 Compass Call EWOs perform very different support tasks from the Wild Weasels. Their role is airborne jamming of enemy radar and command control communication (C3) support for combat strike aircraft. The C3 countermeasures mission belongs primarily to the EC-130 Compass Call, but the EF-111 also can provide C3 coverage. The EC-130 and EF-111 EWOs both employ receivers and warning devices to locate, identify and jam enemy emitters. Such jamming protects penetrating aircraft not equipped for ECM. The goal of the tactical jammers is to electronically blind the enemy to opposing airborne operations. EWOs on the F-4G, EF-111 and EC-130 have access to limited self-defense systems. Their primary mission, however, is ECM support for other aircraft.

The EWO's reconnaissance role is nearly self explanatory. The 'recon' EWO operates special search-analysis receivers. He observes enemy

electromagnetic activity and stores information in computers for further study and evaluation. A thorough knowledge of all types of radar systems enables him to concentrate on important signal emissions without distraction from spurious activity.

Reconnaissance EWOs fly in several variations of the RC-135 aircraft. Duties include operation of search receivers and also supervisory responsibility as tactical coordinators or EW crew commanders.

The Electronic Warfare Officer performs a highly refined skill very critical to the conduct of modern warfare. The rapid new growth of electronic technology promises to make the EWO's job more complex.

One constant in the electronic warfare equation will always be the human operator's role. Computers cannot be programmed to analyze every variable in a modern battlefield. The need for human interface with computers, aircraft, and environment assures the existence of the EWO role well into the future.

Lt Martucci graduated from Franklin and Marshall College in 1979. He completed UNT and EWOT, followed by B-52G CCTS. Since then, Lt Martucci has been assigned to Mather AFB and presently serves as squadron executive officer.

FROM THE EDITOR

Once again we're pleased to offer many fresh and unusual perspectives in this issue. Our lead article, *Fury in the Spice Islands: A Navigator's Mission*, gives me special satisfaction. It relates the experience of an AC-130 navigator who saw action in last fall's rescue of American medical students from the island of Grenada.

The author, Capt Bryan Lasyone, does a masterful job of putting you in the middle of that action. It was a struggle to bring Capt Lasyone's article to publication—a struggle we are happy to have won. His is the kind of message we are eager to share. This kind of experience makes us better warriors.

I am equally proud of this issue's entire contents. If you are an Omega user, you'll value our critical appraisal of that system's operational performance over the past few years as presented in *Omega Update* on page 8. For an account of early combat flights of our navigator/observer predecessors, read *The First Observers*, our centerfold feature. If you tackled our spring issue's quiz, *Indian Ocean Enigma*, then you've been anticipating the solution and accompanying explanation on page 15.

Superstition holds that the number seven can bring luck and good fortune. This issue of THE NAVIGATOR is my seventh and last as editor. I'll be moving back to the operational arena and rejoining the MAC C-130 folks at Little Rock AFB, from whence I came. Your new editor will be Capt Jon Scott. As a former FB-111 rightseater, Jon brings a WSO's perspective to this job and, I'm sure, he will maintain THE NAVIGATOR's tradition of excellence. However, he will rely upon your support.

I offer thanks to everyone who helped me with manuscripts, feedback, and moral support. Several of you contributed regularly with fine articles. You've been the magazine's backbone. I can't thank you enough. But we need support from everyone. If you've even been remotely thinking of writing an article for us, by all means, do it! You will benefit yourself and your profession, and you'll probably reap some enjoyment in the bargain.

Two years have run their course since I became THE NAVIGATOR's editor. The passage of that time brought challenges, changes, and cheers. But mostly these past two years have shown me that every navigator's potential is limited only by each individual. Set your goals, keep striving, and keep reading THE NAVIGATOR.

THE NAVIGATOR AUTHOR'S GUIDE

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HOW TO PREPARE AN ARTICLE: Length is optional, but please doublespace your manuscripts. We assume exclusive right of publication so be sure to inform us if you submitted your manuscript to other publications. Avoid excessive use of long sentences, jargon, and acronyms. Write for the navigator in training or the individual aspiring to become a navigator. Provide large black-and-white, glossy photographs, if available, or suggest appropriate illustrations. Your roughly-drawn illustrations will be refined by our production editor. Number pages and identify photos, charts, figures, or illustrations.

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FOR ASSISTANCE: Write or call us at AUTOVON 828-2138/2089, commercial (916) 364-2138. We are always glad to help with an article at any stage of production, from the basic idea to the polished draft.

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